Comparisons of

ACE-FTS and MLS v4.2

atmospheric profiles and drift analysis

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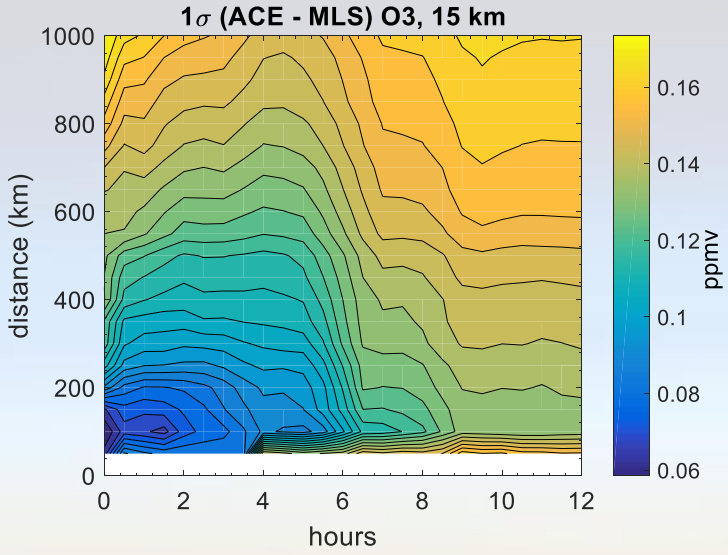
Aura science team meeting, 1 Sept 2016, Rotterdam, Netherlands

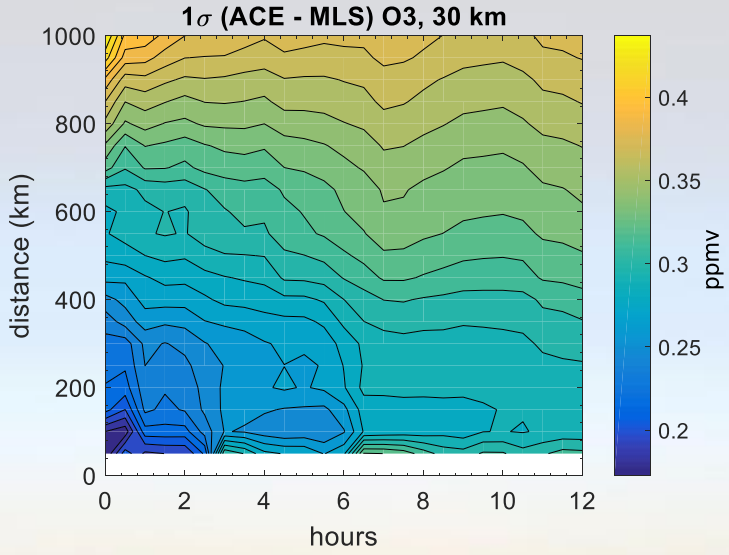
ACE-FTS

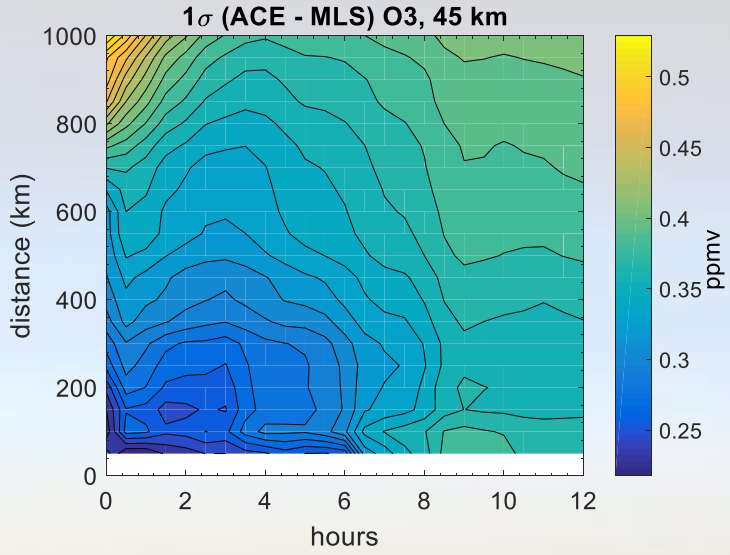
Atmospheric Chemistry Experiment – Fourier Transform Spectrometer

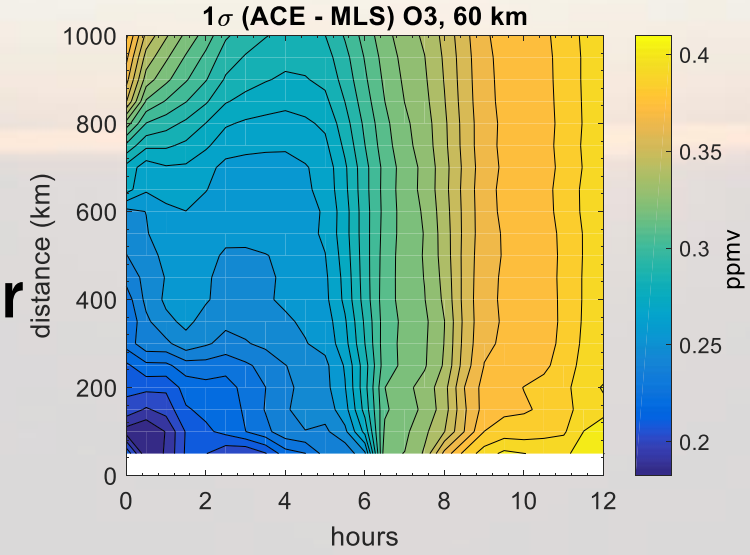
- Canadian satellite SciSat was launched into a circular, high-inclination orbit in August 2003
  - ACE-FTS and MAESTRO instruments on board
- ACE-FTS is a solar occultation instrument
  - High spectral resolution FTS in the 2.2 to 13.3 μm spectral range
  - 30+ trace species are retrieved, as well as 20+ subsidiary isotopologues
  - Vertical resolution of 3-4 km
- ACE-FTS level 2 version 3.5 data were used in this study
  - Complete dataset currently spans 2004-2013
  - Data set supplemented with Jan-Apr 2016 data (not yet released)
- Species in common with MLS
  - O_3, H_2O, N_2O, HCl, HNO_3, CO, HCN, CH_3Cl, CH_3OH

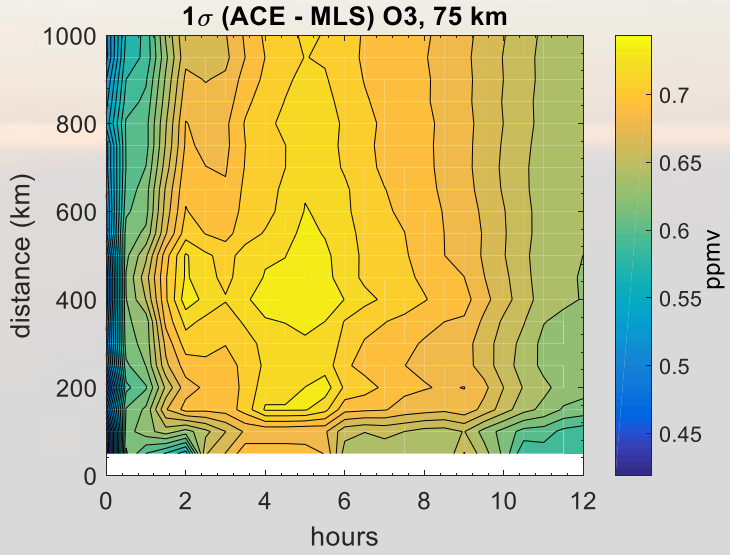
Coincidence criteria with MLS











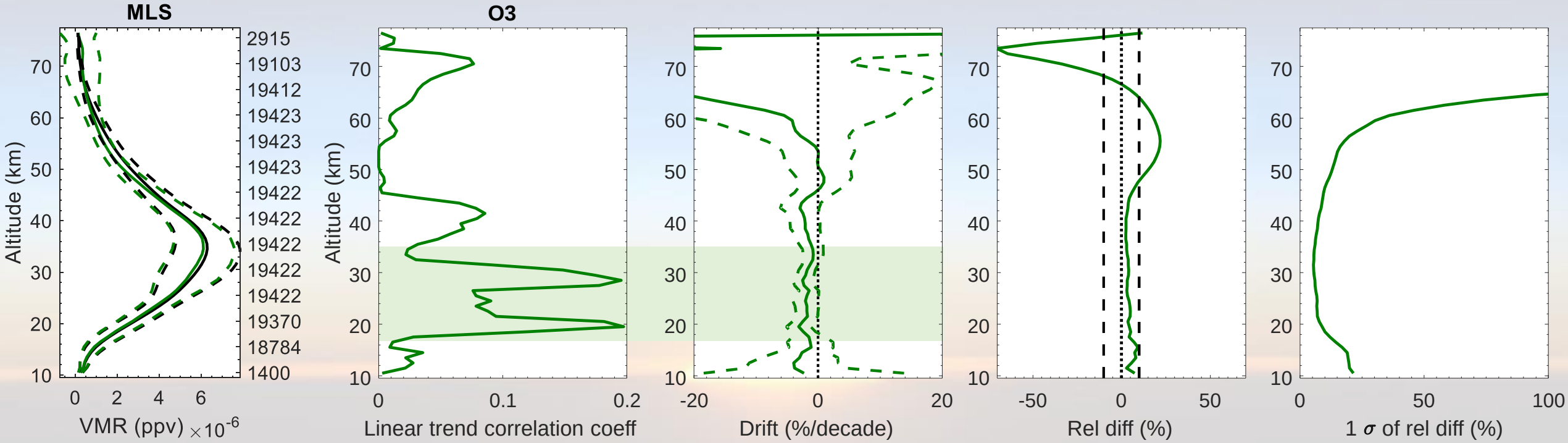
- Plots of (ACE-FTS – MLS) O_3 variation as a function of coincidence criteria
- Trade off between number of coincidences and geophysical variation
  - Chose coincidence criteria of within ±6 h, ±500 km

Drift analysis

- All coincidences from 2004-2013 and 2016
- Monthly means of relative differences (ACE-FTS – MLS)
- Take linear fit, 99.9% confidence in slope as error bounds
- Calculate linear fit correlation

- Breakpoint analysis
  - Vary breakpoint between 2005 and 2012
  - Calculate slope and correlation for data before and after breakpoint
  - Calculate overall correlation with and without breakpoint
    - If correlation is significantly greater with breakpoint, then there's a valid breakpoint!
    - SPOILER ALERT: no valid breakpoints were found. ☹

O_3 ACE-FTS – MLS

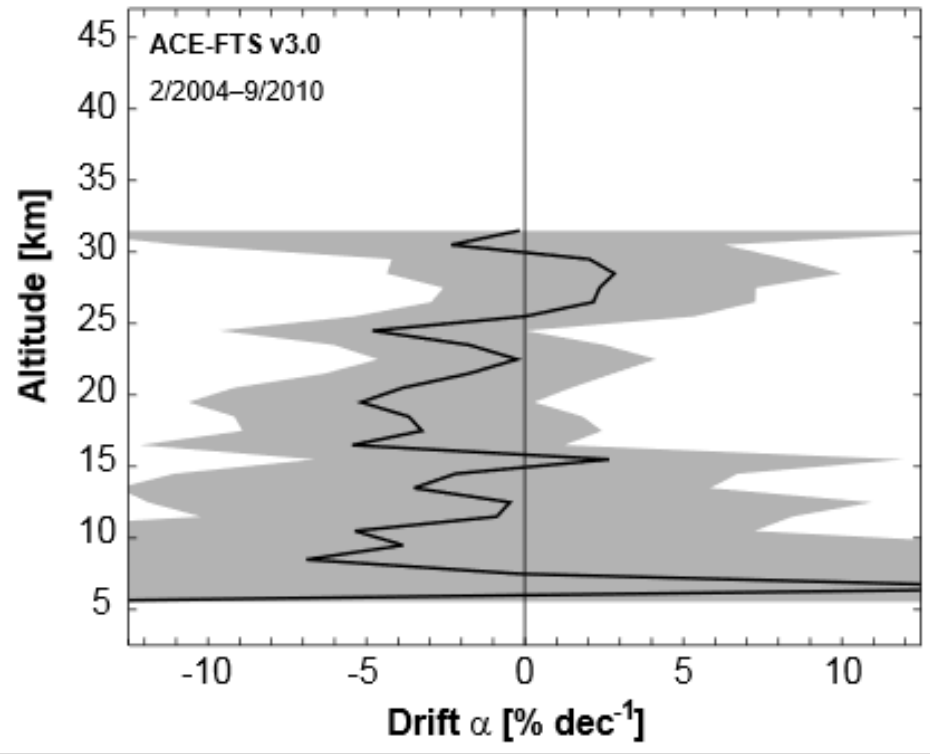


- ACE-FTS O_3 has a known high bias
  - ~2% in stratosphere
  - ~10-20% in lower mesosphere
- Drift is close to significant in the 20-30 km region, ~ -0.13±0.08 ppmv/decade

ACE-FTS O_3 vs ozonesondes

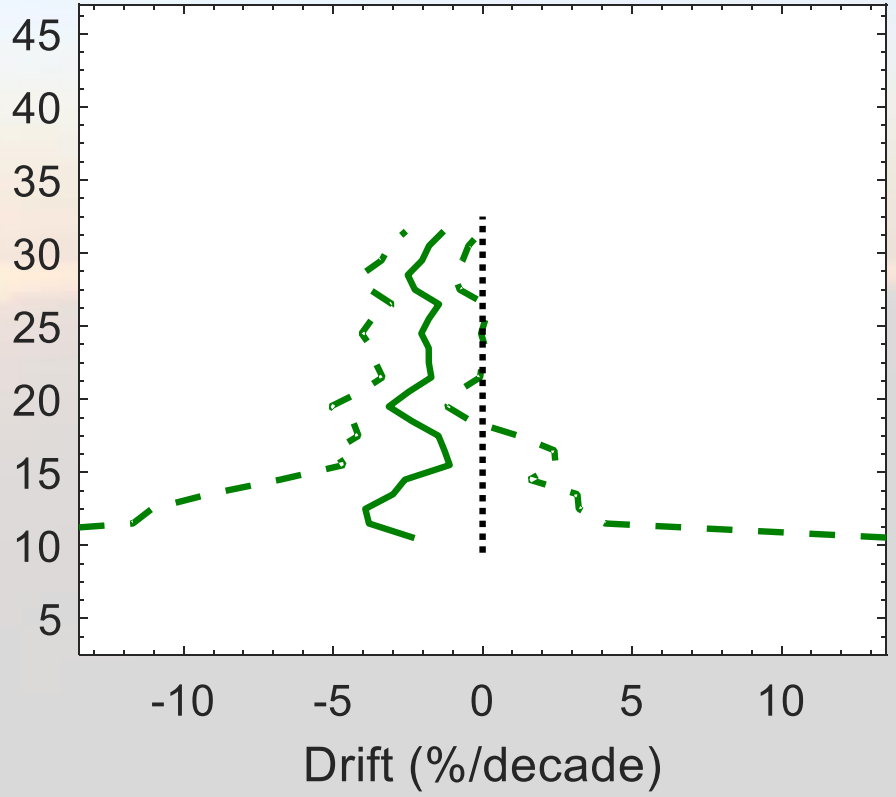
From *Hubert et al., AMT, 2016*

- Typically better than -5%/dec
- Only 2004-2010 data used



ACE-FTS – MLS

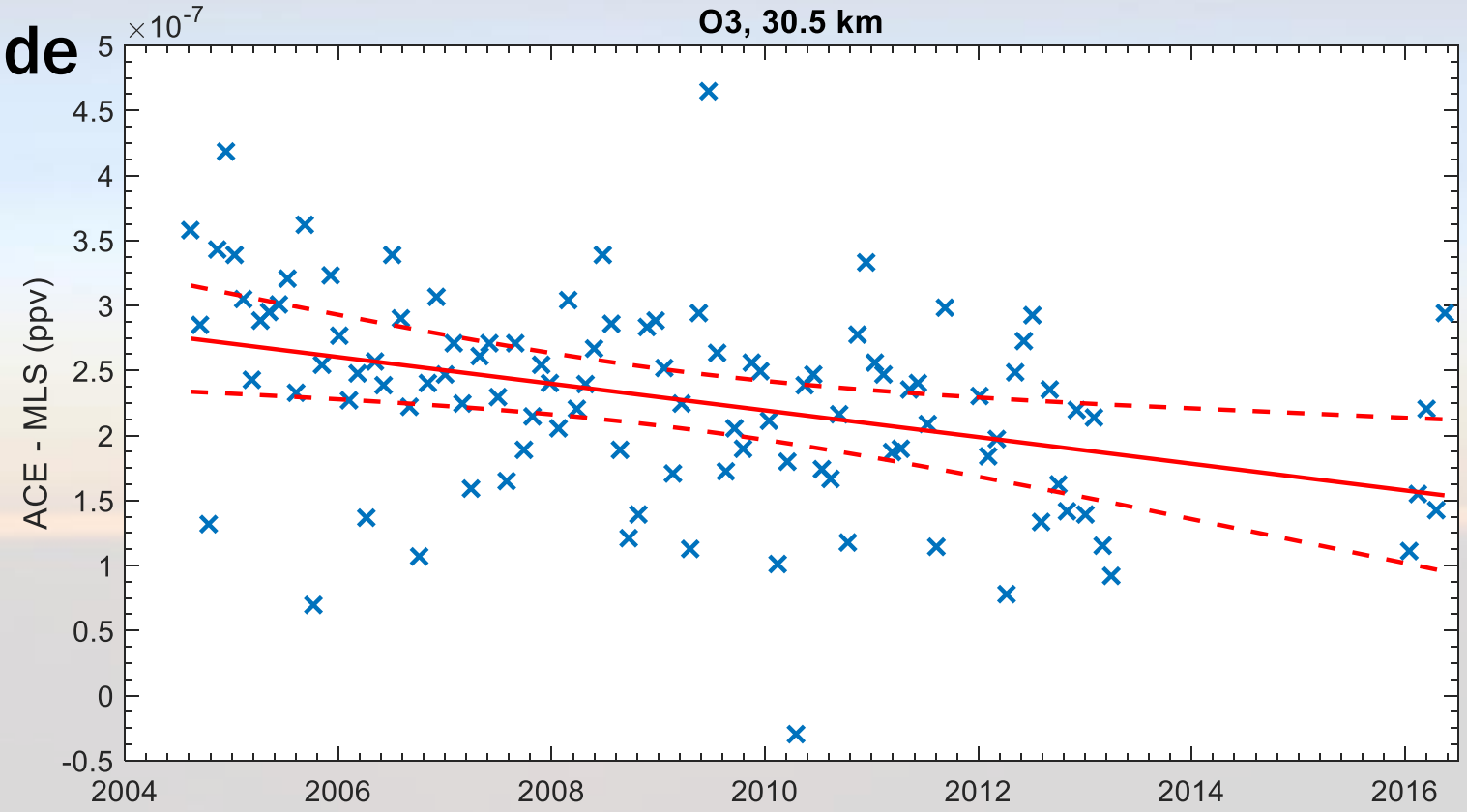
- Typically –3%/dec
- 2004-2013 + 2016



O_3

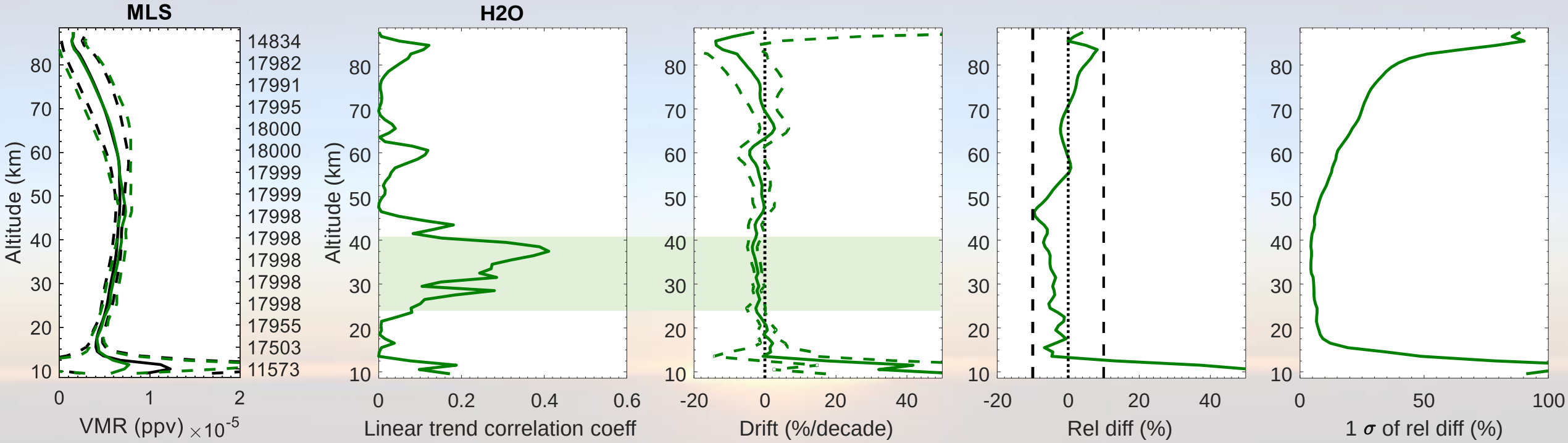
ACE-FTS – MLS

- ~2-3% / decade



H_2O

ACE-FTS – MLS

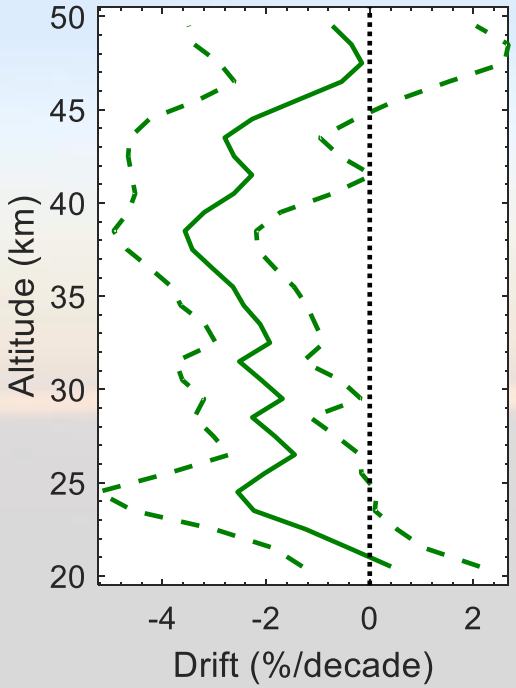


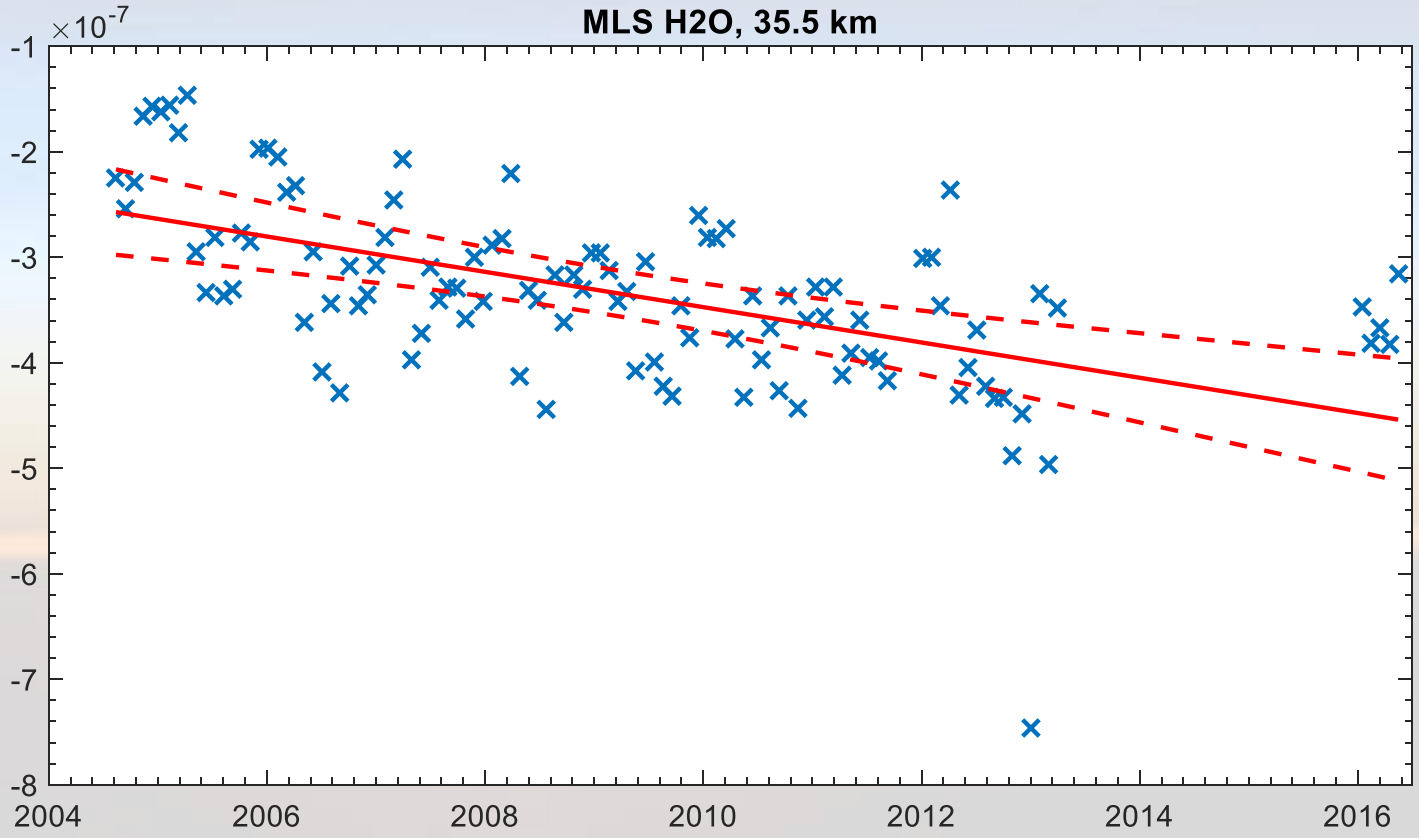
- ACE-FTS has dry bias in stratosphere above the hygropause
- Negative drift near 25-40 km ~0.2±0.1 ppmv/decade

H_2O

ACE-FTS – MLS

- ~2-4% / dec

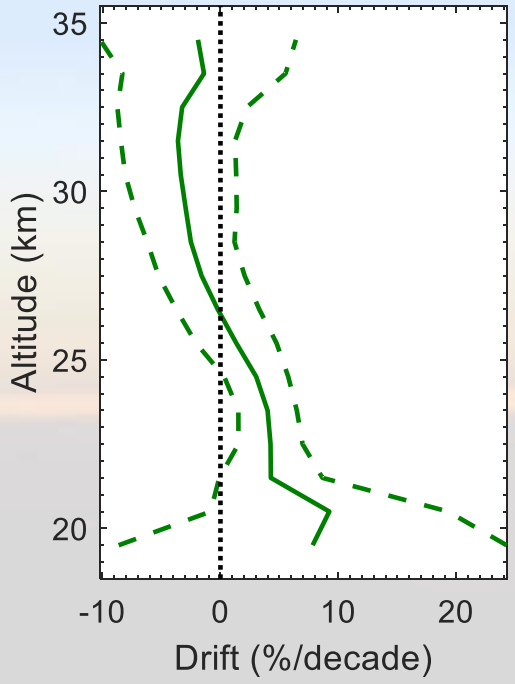


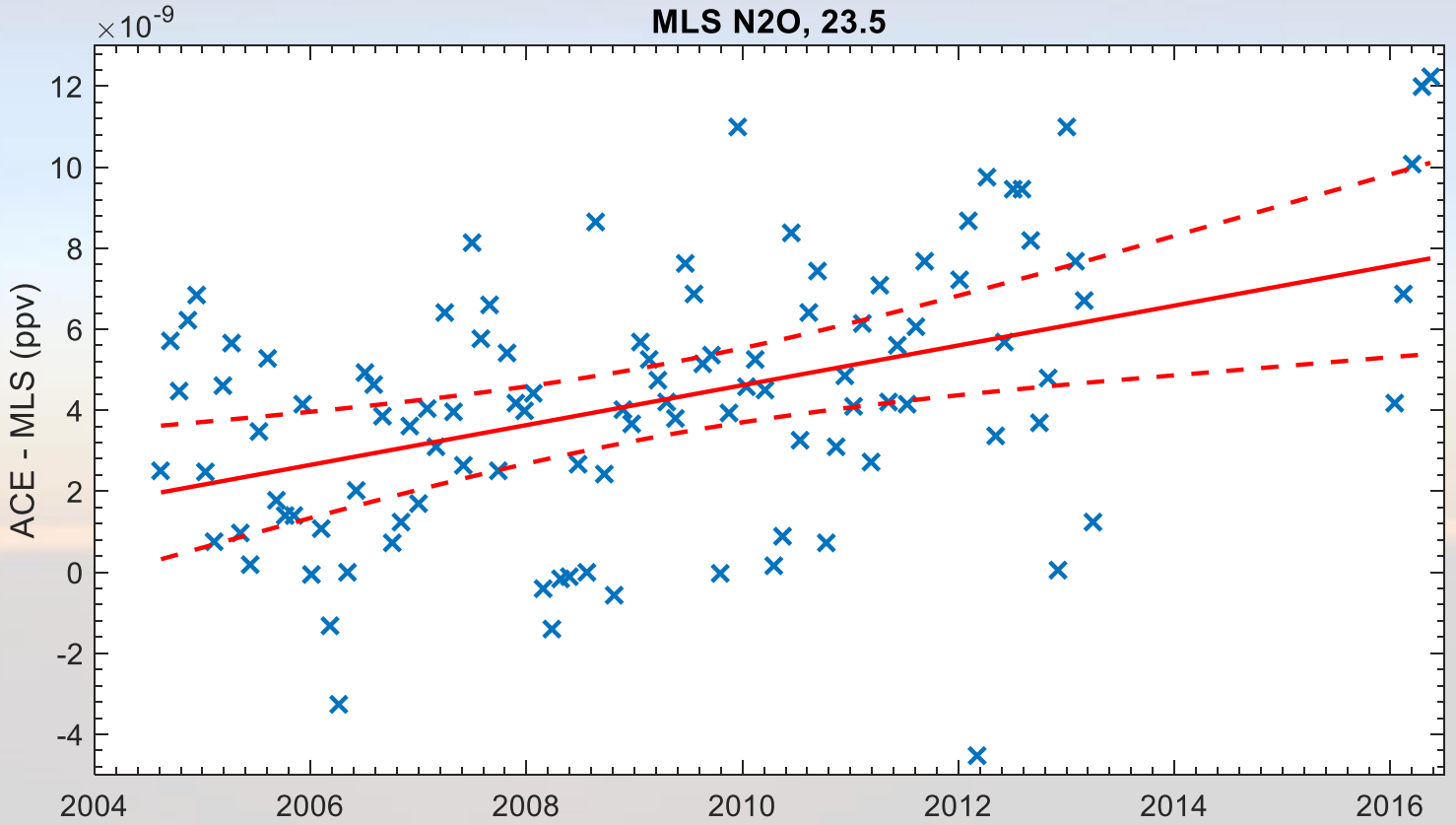


N_2O

ACE-FTS – MLS

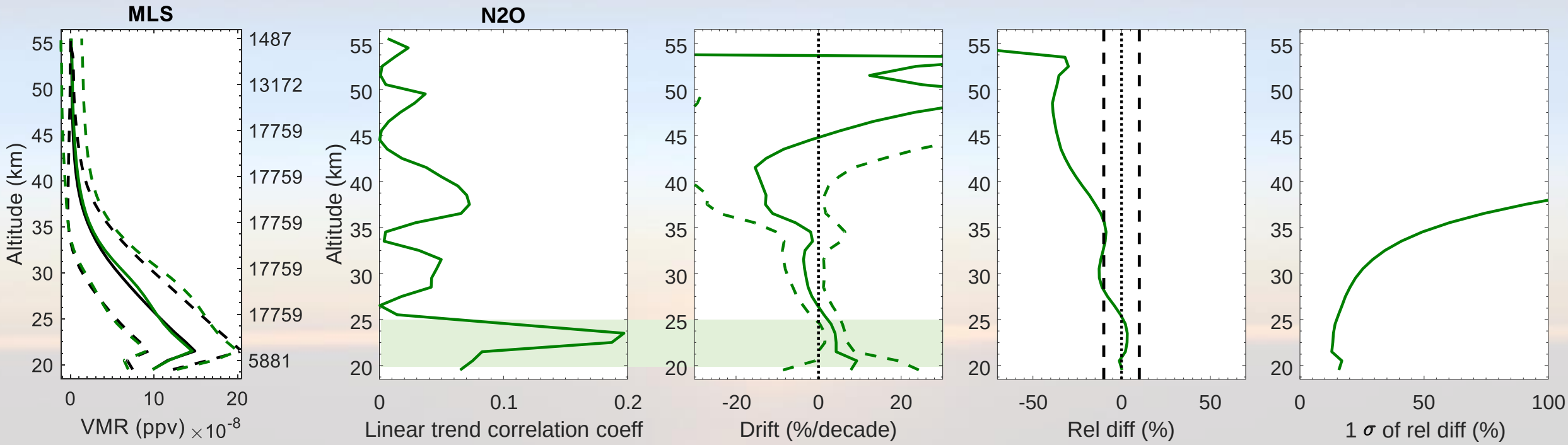
- ~4%/decade





N_2O

ACE-FTS – MLS

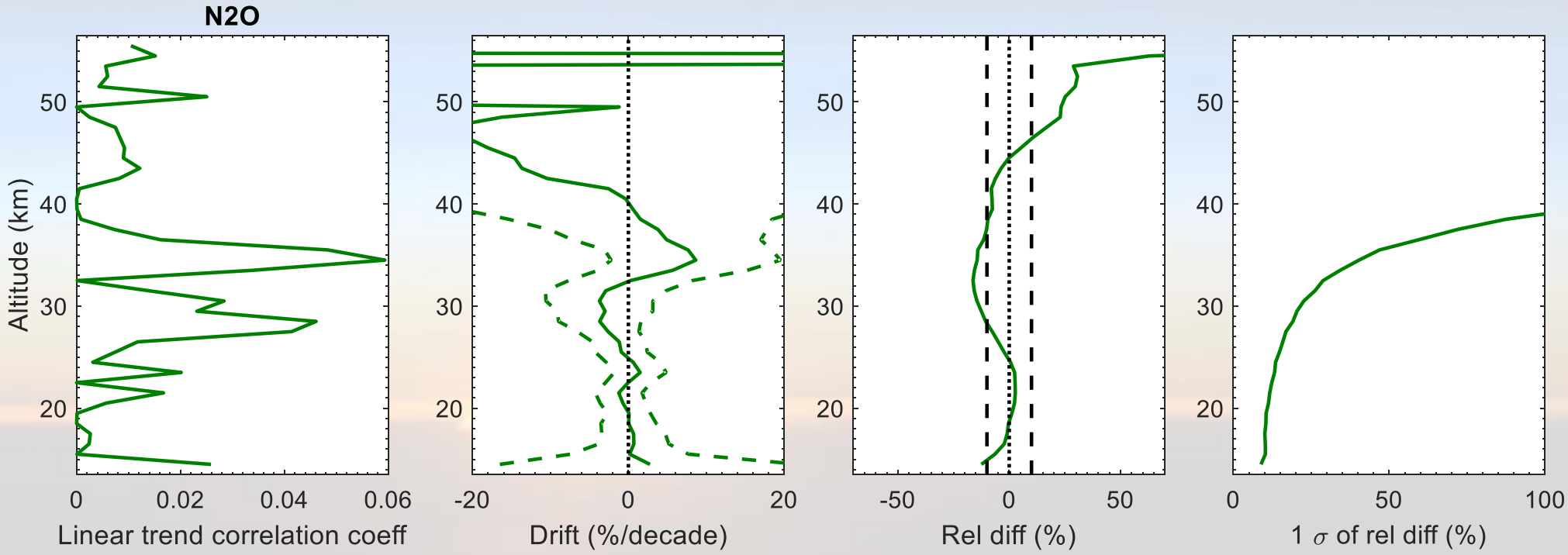


- Agree within ±3% below 26 km; ACE-FTS is ~10% smaller near 28-35 km
- Positive drift of ~5 ppbv/decade near 23 km

N_2O

ACE-FTS – MLS v3

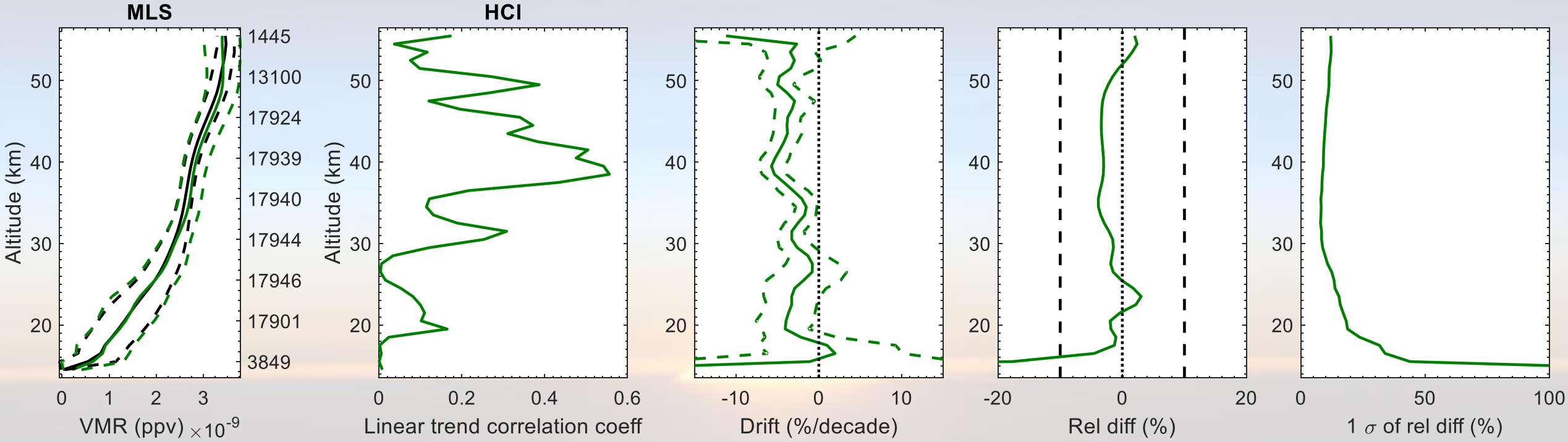
NOTE: Lower altitude limits are different between v3 and v4!



- No significant drift is found when comparing ACE-FTS and MLS v3 N_2O
  - v3 N_2O uses the 640 GHz channel, v4 uses 190 GHz

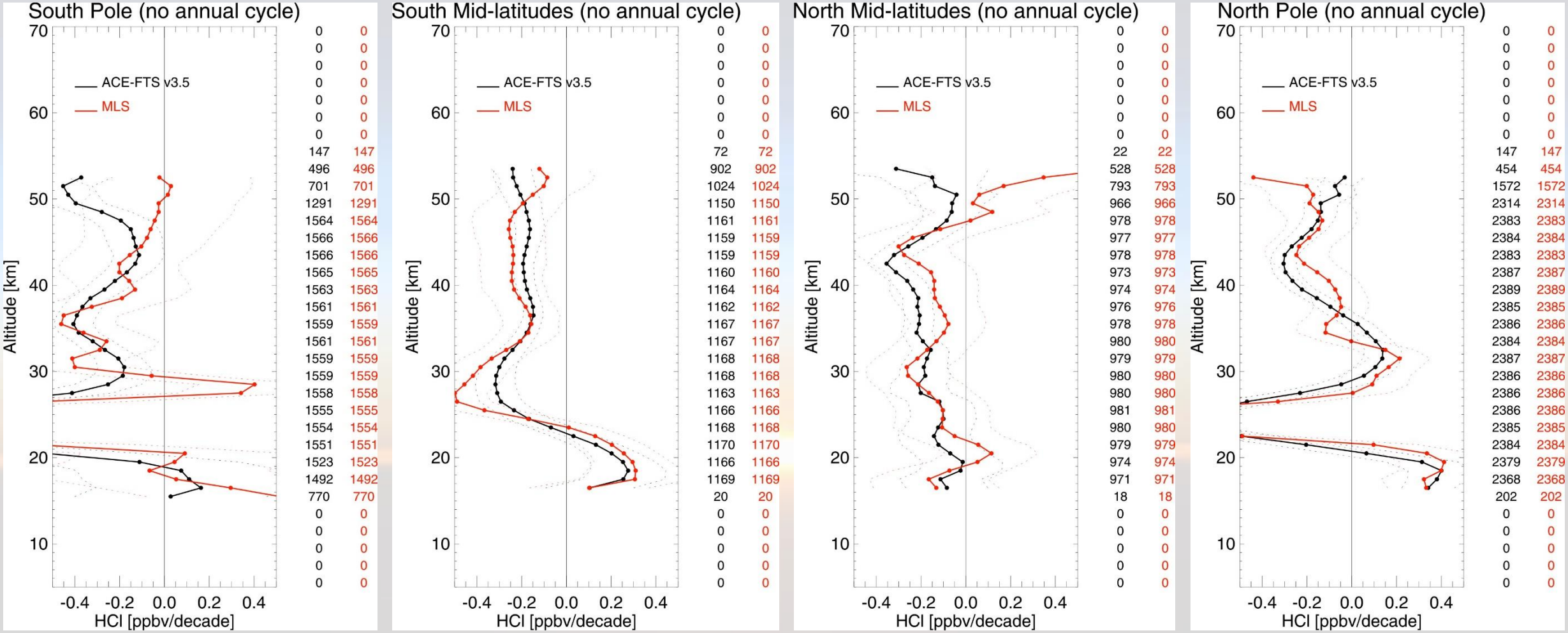
HCl

ACE-FTS – MLS



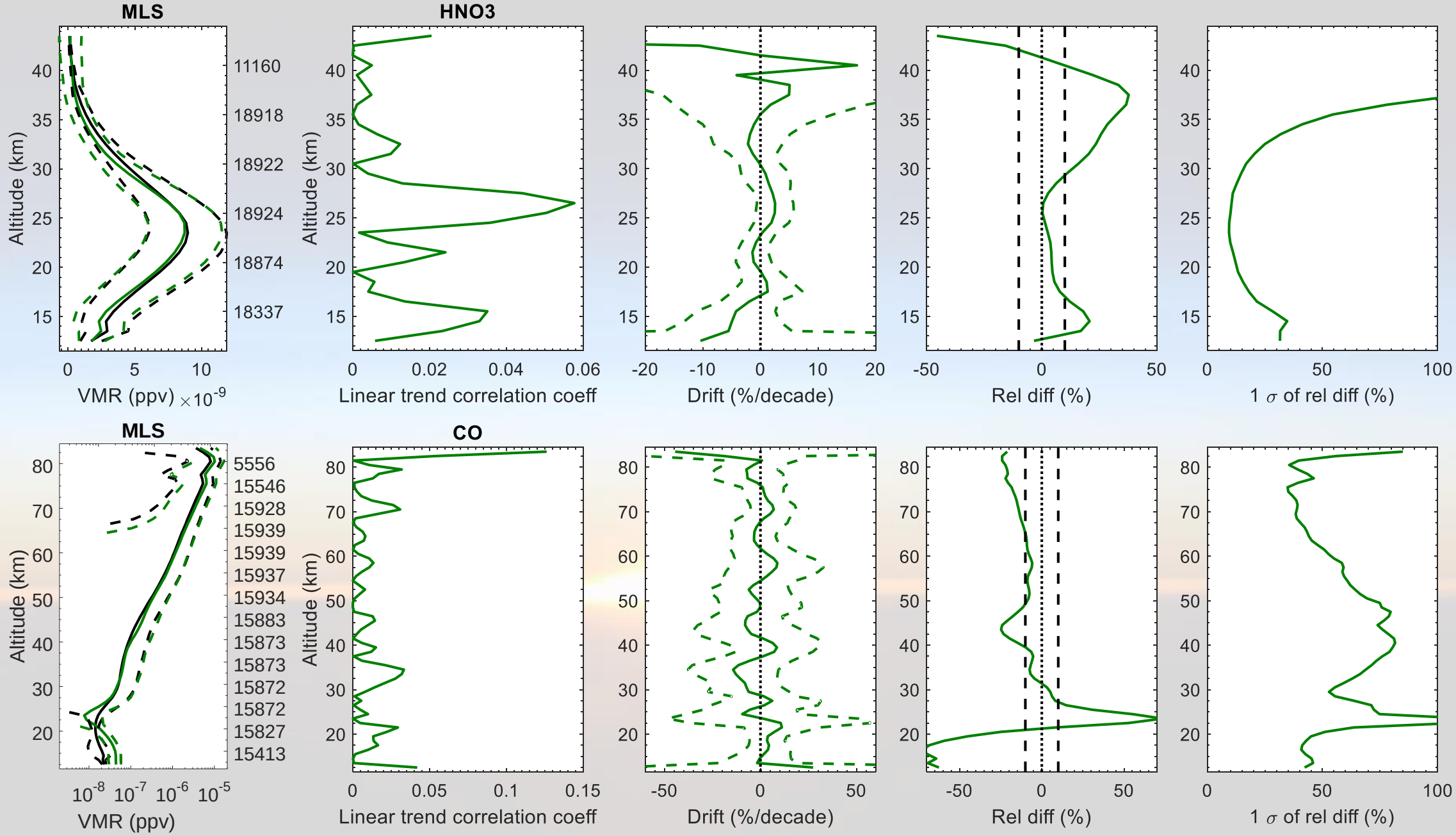
- Typically agree within ±5%
- In upper stratosphere, MLS HCl (band 14) is known to not be of "trend quality"

HCl band 13



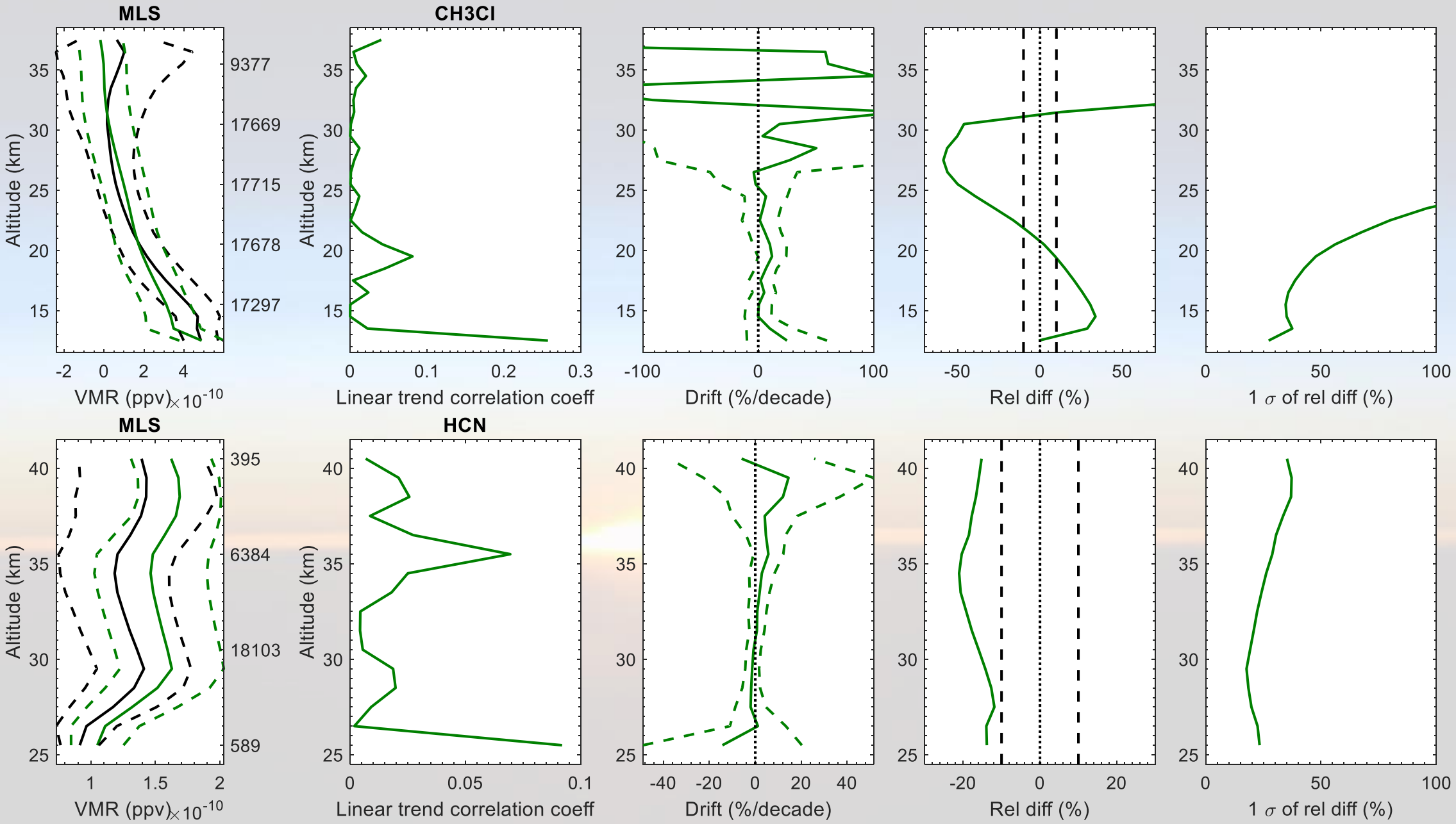
- Rate of change at 4 latitude bands using coincident points between ACE-FTS v3.5 and MLS v4.2 (no coincident points for 2009 and 2010 in tropics) derived from data with annual cycle removed

No significant drift



- **For CO summer months (Jun-Aug in NH; Dec-Jan in SH) have been excluded**
  - **MLS summer CO tends to be much noisier**

No significant drift



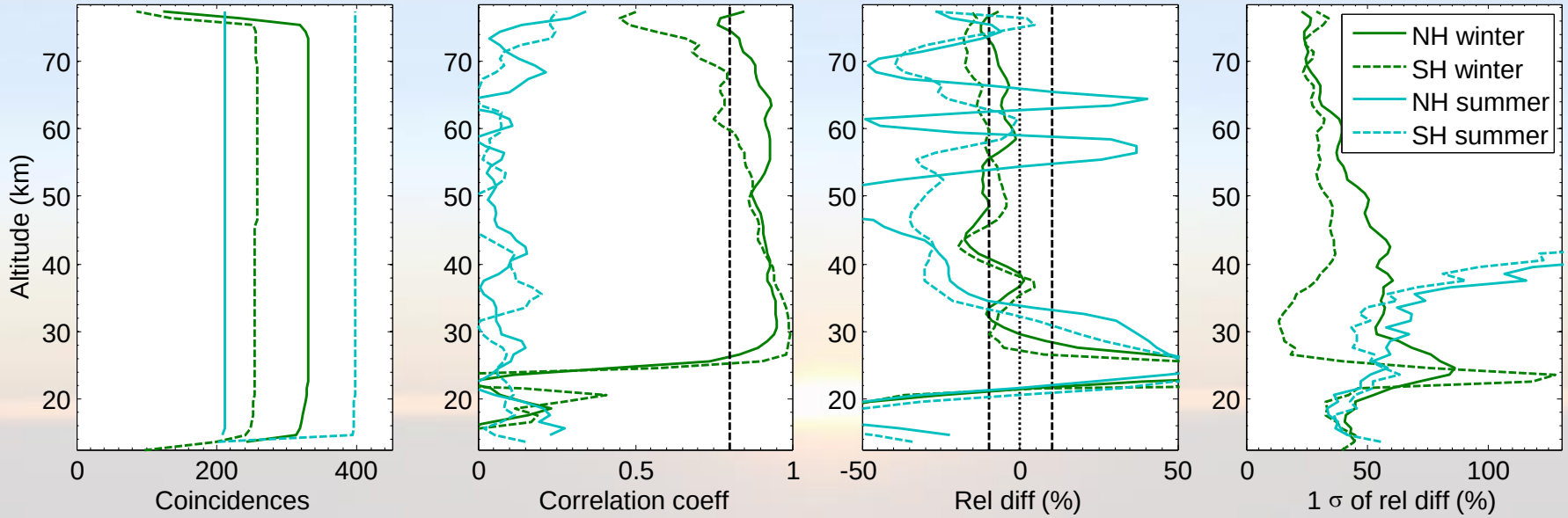
Conclusions

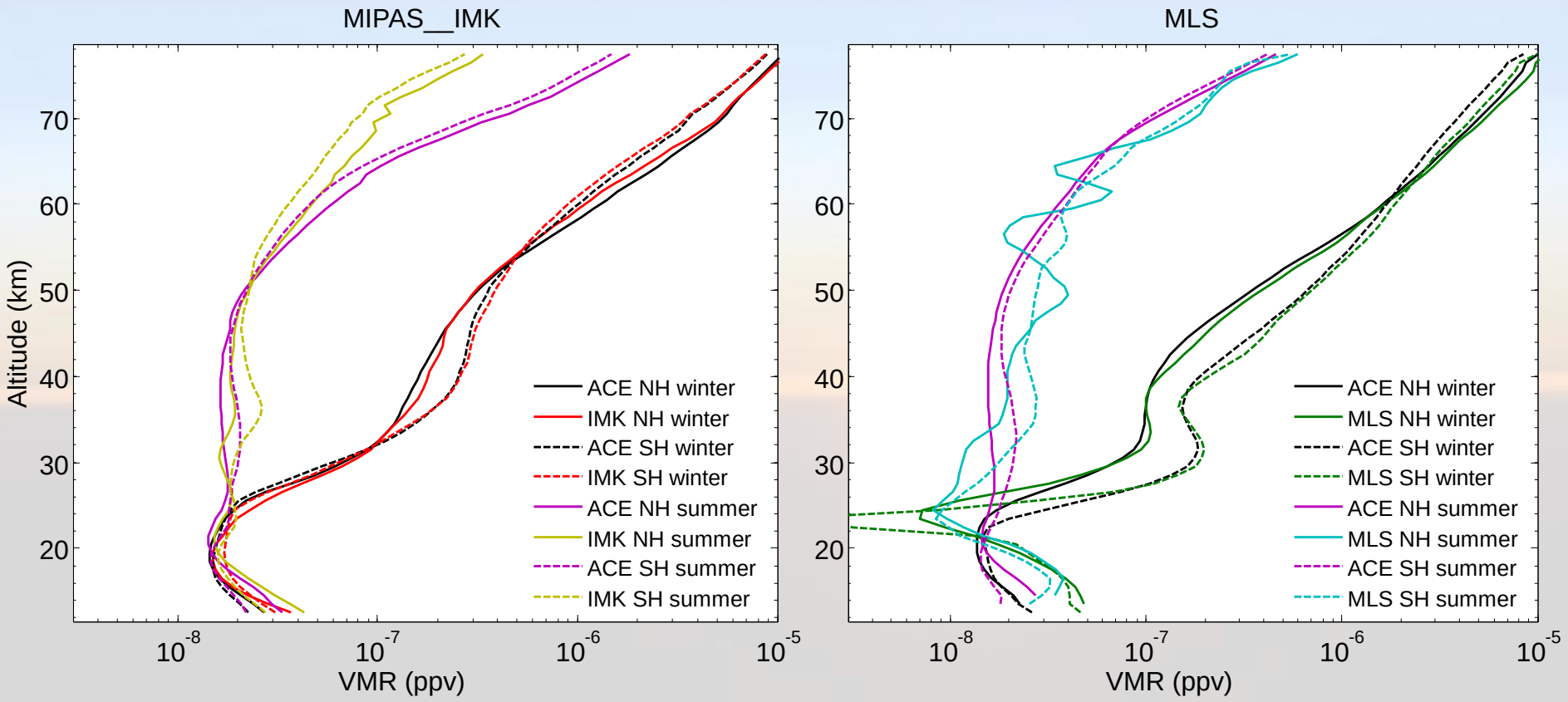
- Just reporting the amount of drift in comparison with MLS v4.2
  - No definitive explanations yet for the existence of drifts
- A match made in the heavens
  - Just like any good long term relationship, ACE-FTS and MLS are, for the most part, in sync; but in certain areas they're drifting apart
- No significant drift found in HNO_3, CO, HCN, CH_3Cl

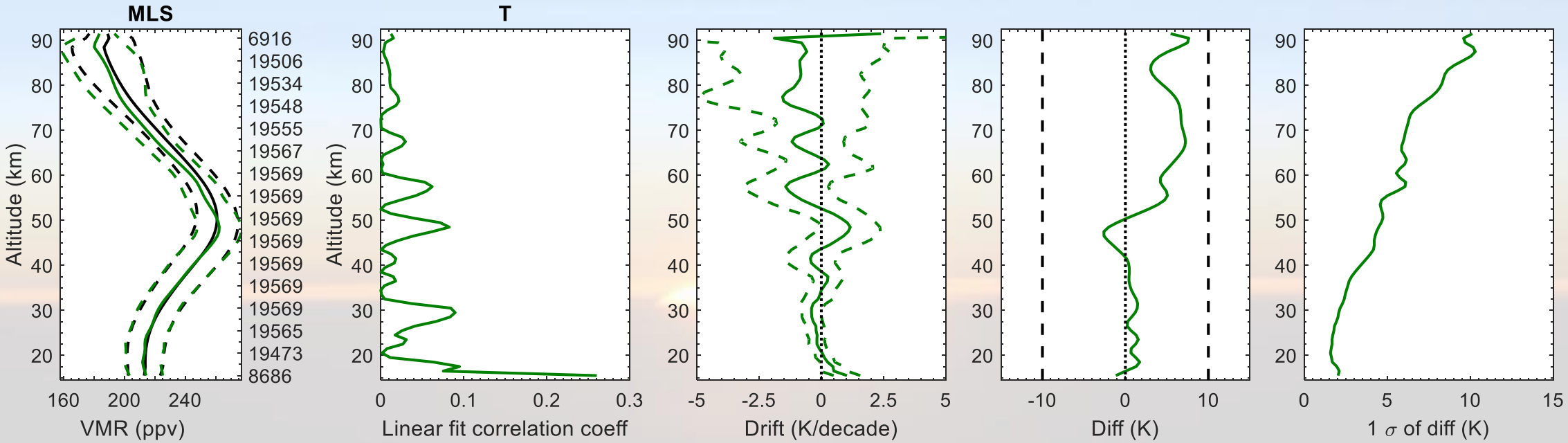
- Significant drift found in:
  - O_3 – negative drift on order of 2-3%/dec near 20-30 km - likely an ACE issue
  - H_2O – negative drift on order of 2-4%/dec near 20-45 km - possibly an MLS issue
  - N_2O – positive drift on order of 4%/dec near 23 km - likely an MLS 190-GHz issue

Thanks!

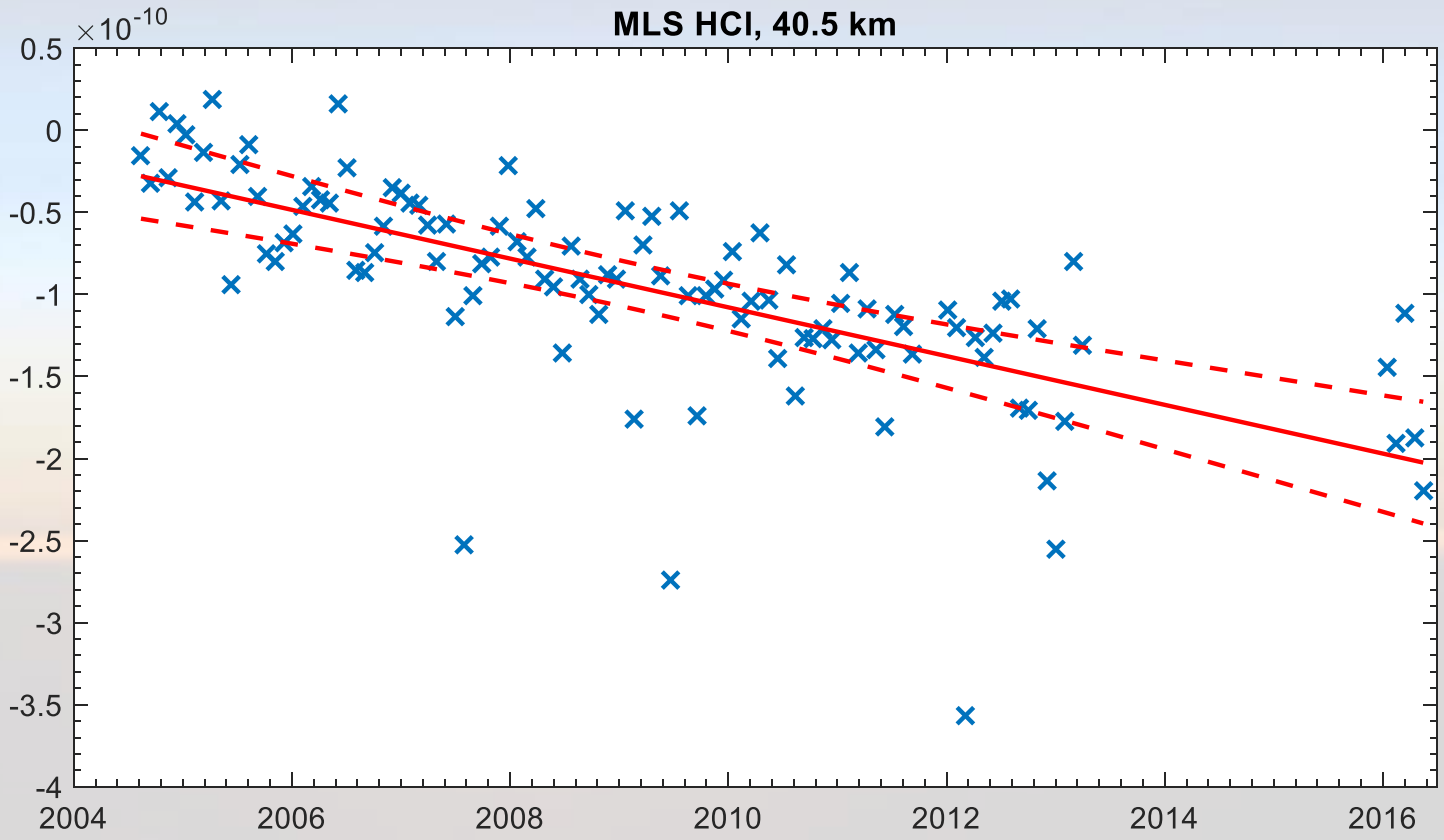
The extra bits


Altitude (km)
70
60
50
40
30
20
0
200
400
Coincidences
0
0.5
1
Correlation coeff
-50
0
50
Rel diff (%)
0
50
100
1 σ of rel diff (%)
NH winter
SH winter
NH summer
SH summer


MIPAS__IMK
MLS
Altitude (km)
70
60
50
40
30
20
10^{-8}
10^{-7}
10^{-6}
10^{-5}
VMR (ppv)
ACE NH winter
IMK NH winter
ACE SH winter
IMK SH winter
ACE NH summer
IMK NH summer
ACE SH summer
IMK SH summer
MLS NH winter
MLS SH winter
MLS NH summer
MLS SH summer


MLS
T
Altitude (km)
VMR (ppv)
Linear fit correlation coeff
Drift (K/decade)
Diff (K)
1 σ of diff (K)
6916
19506
19534
19548
19555
19567
19569
19569
19569
19569
19569
19569
19569
19565
19473
8686

HCl


MLS HCl, 40.5 km
×10^-10
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
2004
2006
2008
2010
2012
2014
2016